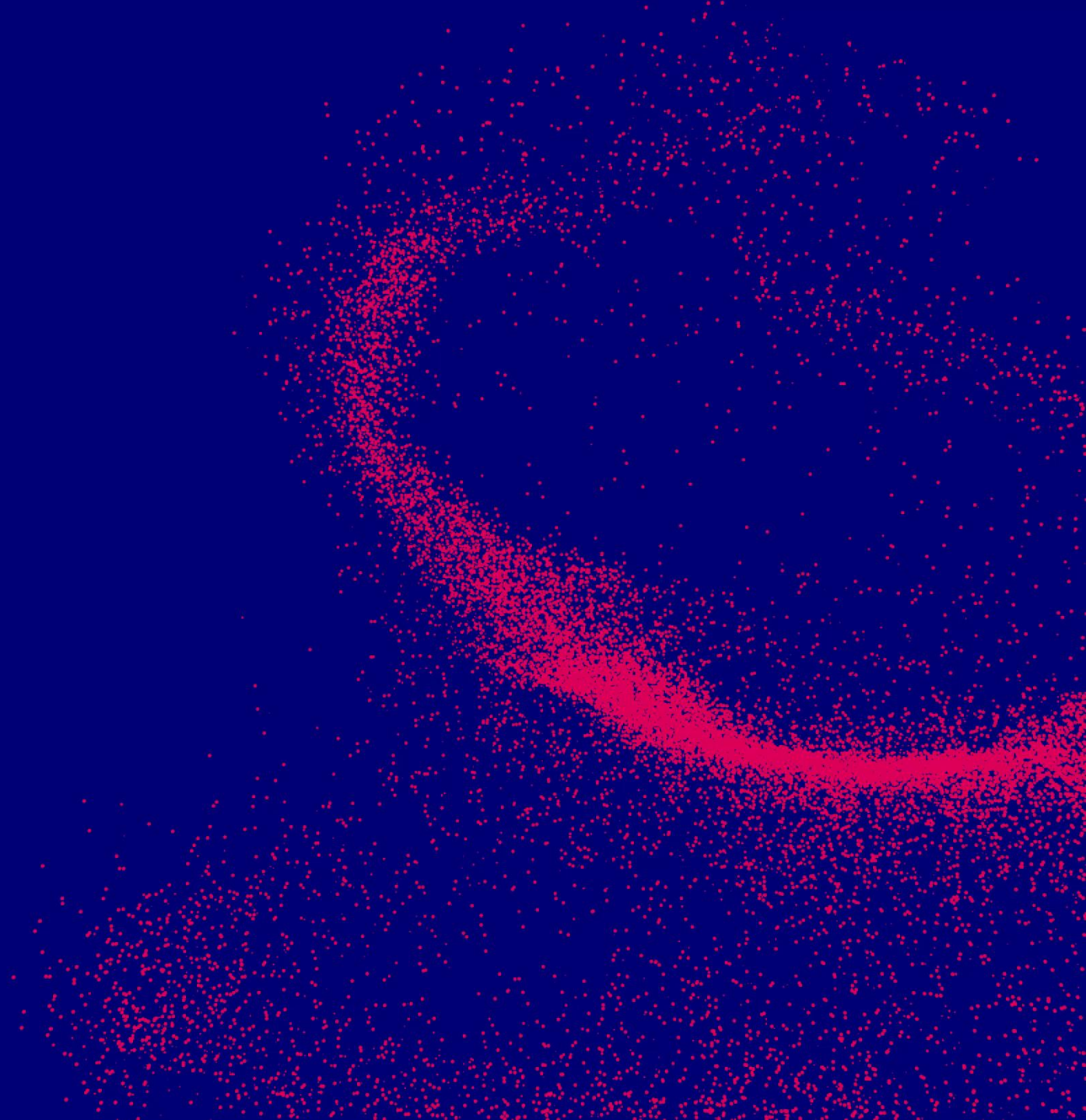
PSI

TATOOS



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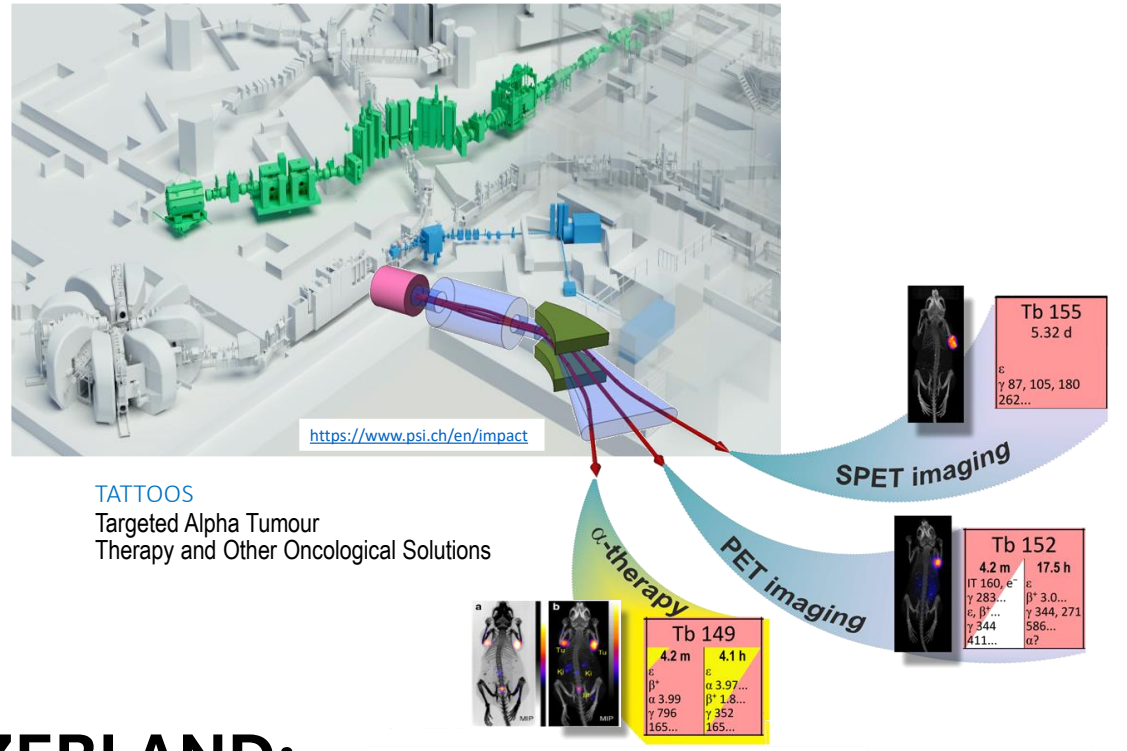


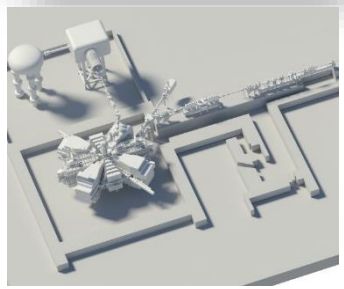
IMPACT-TATTOOS

Novel radionuclide production in SWITZERLAND: a design status report

Robert Eichler :: Laboratory of Radiochemistry & University of Bern for the IMPACT collaboration

PRISMAP Radiolanthanide Workshop August 3 – August 6 2024, Villigen , PSI, Switzerland

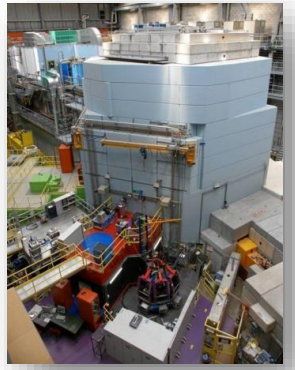
IPII



"*Terbium Sisters*" for Theragnostics: Terbium A Multi-Purpose Element

PSI

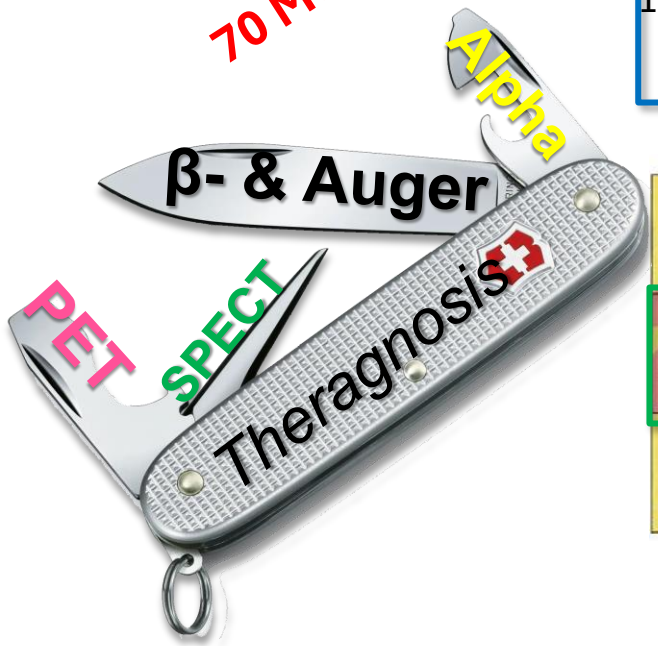
SINQ (NIS)

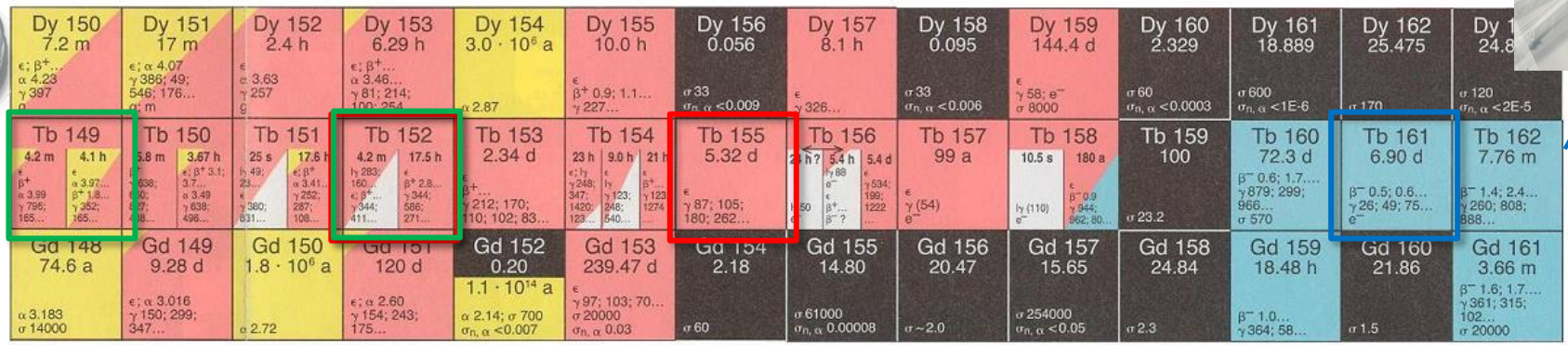


Isotope	$T_{1/2}$	Decay mode	Potential use
^{149}Tb	4.1 h	α (3.6 MeV); $β^+$ (800 keV)	α-particle therapy
^{152}Tb	17.5 h	$β^+$ (1275 keV)	PET
^{155}Tb	5.32 d	γ (87, 105 … keV)	SPECT
^{161}Tb	6.88 d	$β^-$ (593 keV)	$β^-$-particle & Auger electron therapy

?

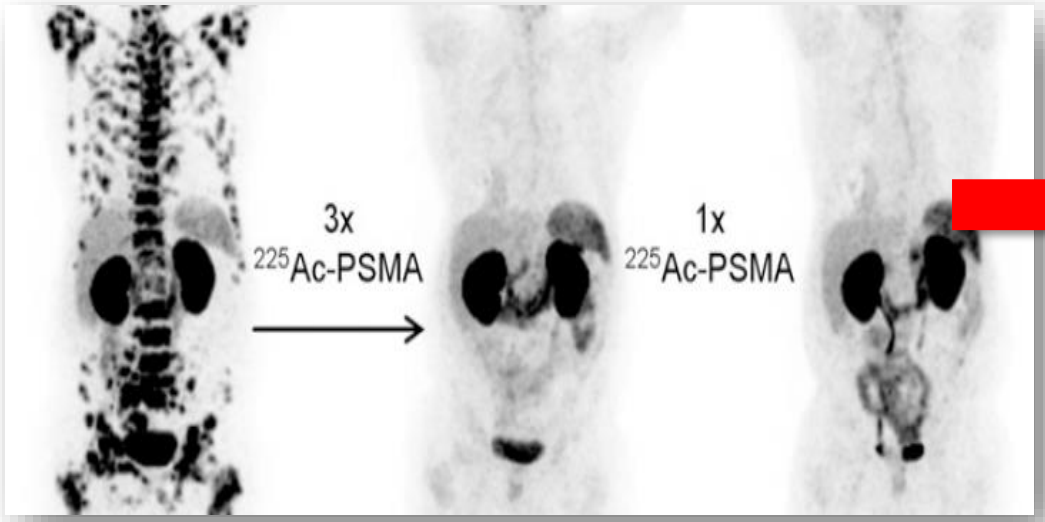
70 MeV PROTONs

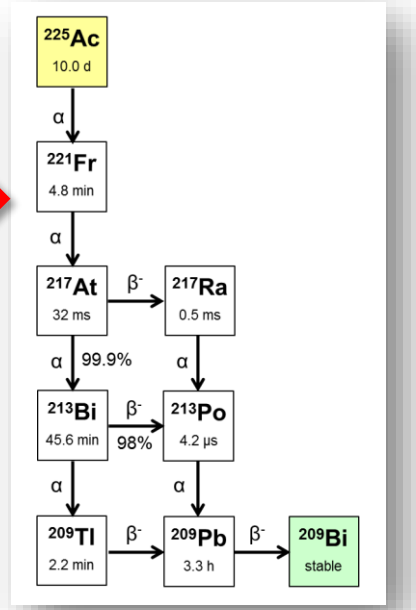




NEUTRONs

Targeted Alpha Therapy is a Hot Topic!



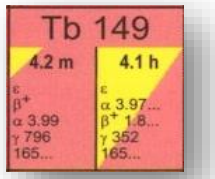


Kidney
& Salivary glands

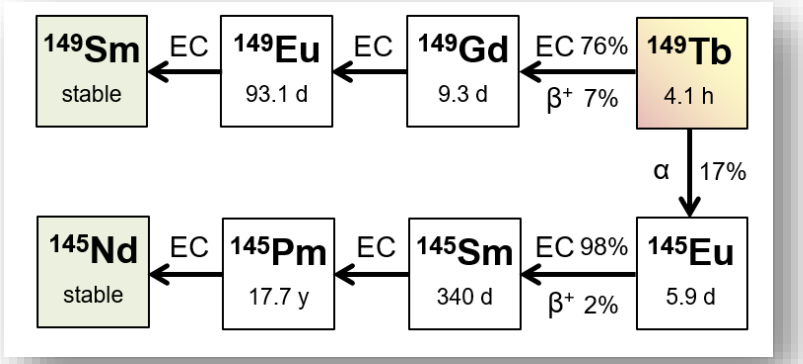
Multiple α/β^--decaying daughter nuclides can cause much damage,
Resulting in side effects!

4h half-life / alpha & beta+ decay

Transport loss
between Geneva and PSI:
50% → ~200 MBq
→barely enough for
preclinical (animal) studies



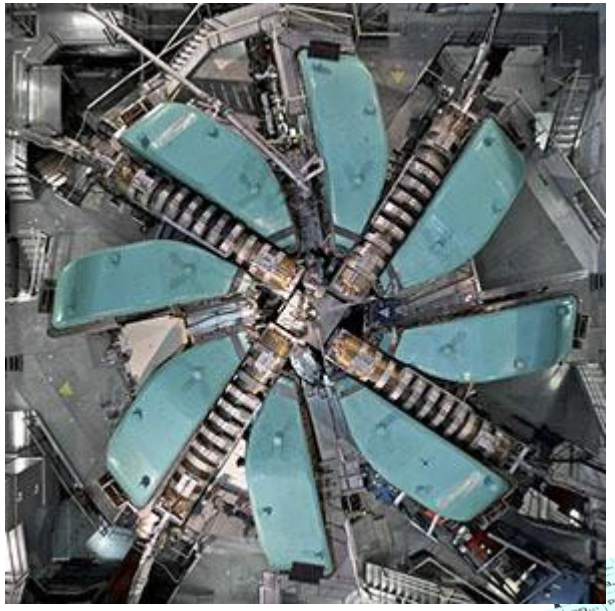
^{149}Tb has NO α-daughters!



Umbricht et al. , Scientific Reports, 2019

^{149}Tb Production @ PSI-HIPA

World's most powerful DC beam of 2.2 mA 590 MeV protons @ PSI

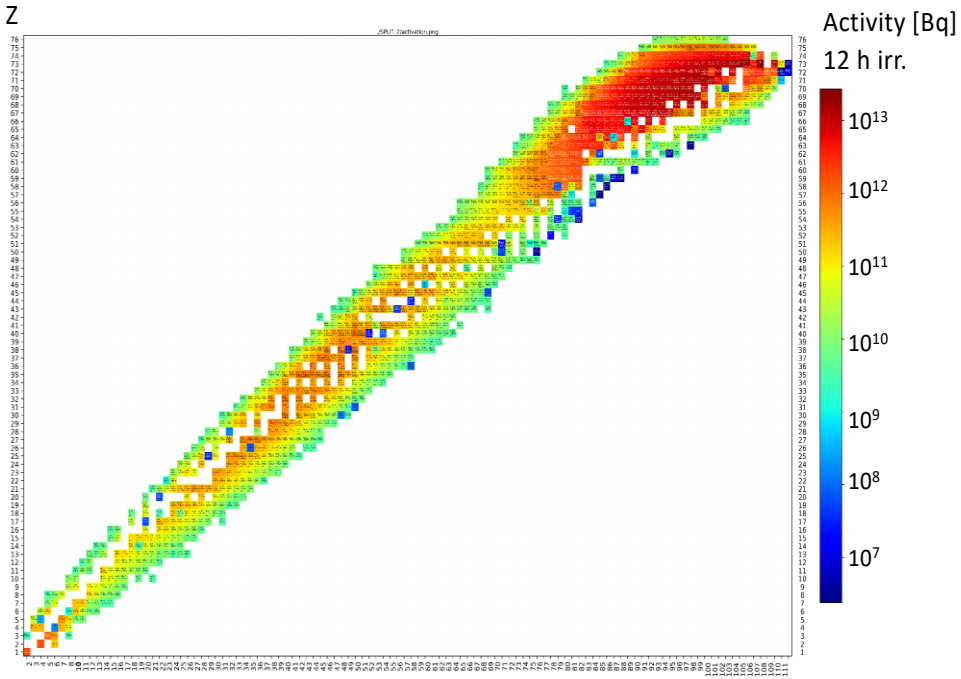


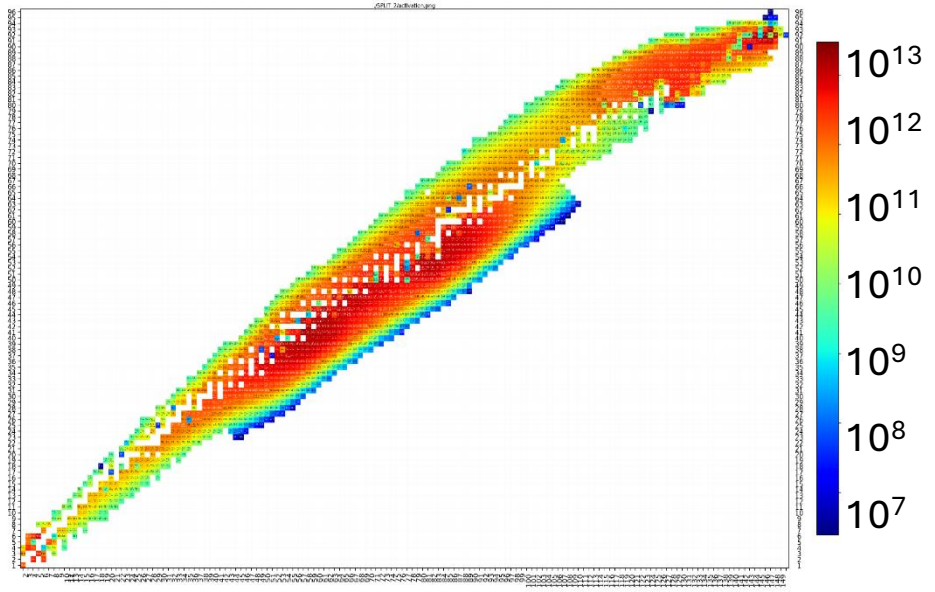
^{181}Ta(p,10p & 20/23 n)^{149,152}Tb

https://people.physics.anu.edu.au/~ecs103/chart3d/

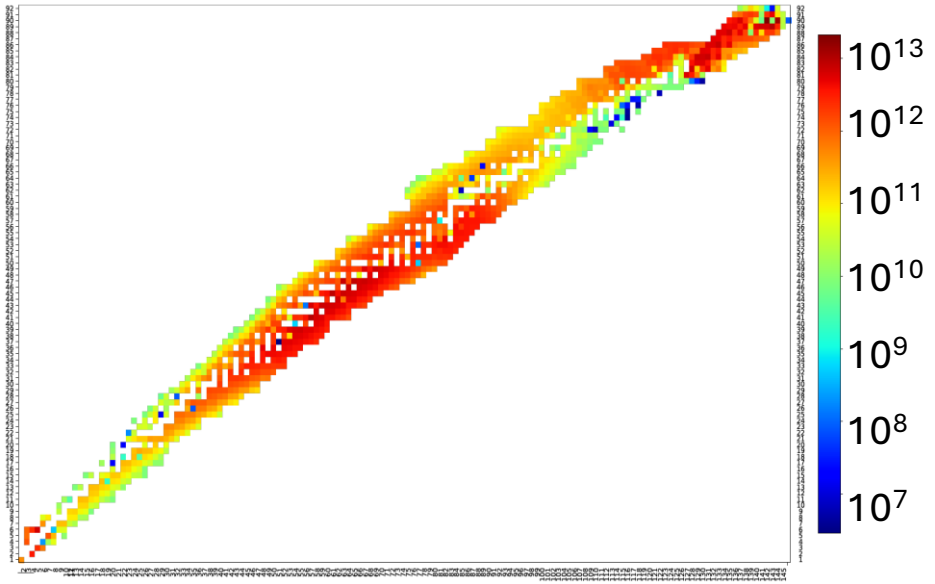
Production of Radionuclides in Spallation

Tantalum 12 h irradiation





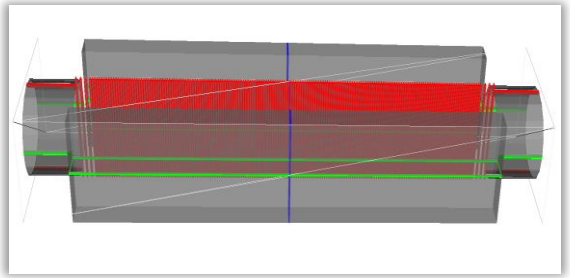
Activity [Bq]
6 d irr. **Uranium**



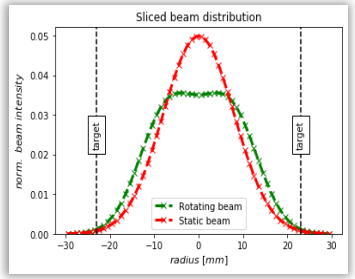
Activity [Bq]
6 d irr. **Thorium**

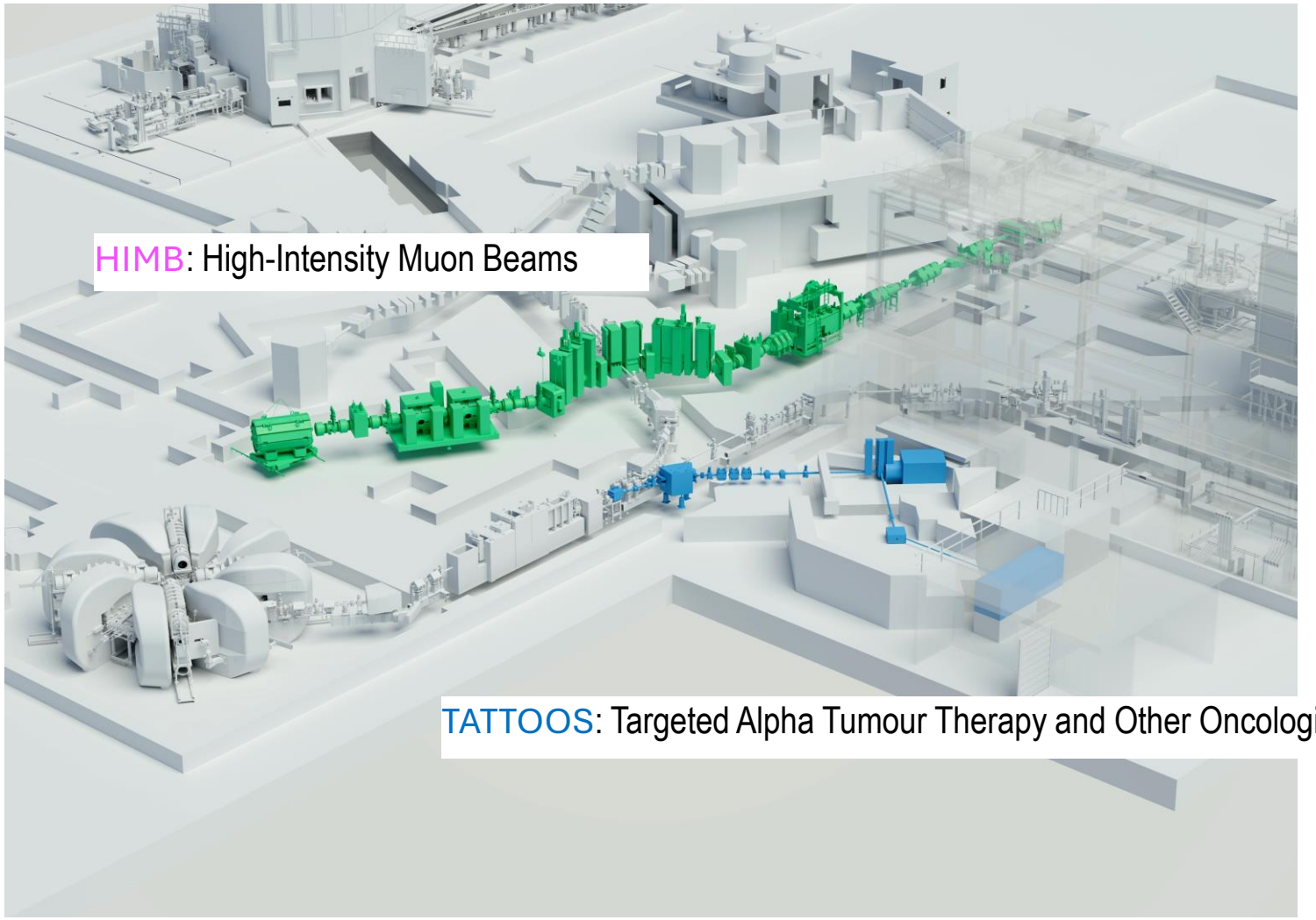
The IMPACT Project 2021

Beam splitter for 100 μA 590 MeV p

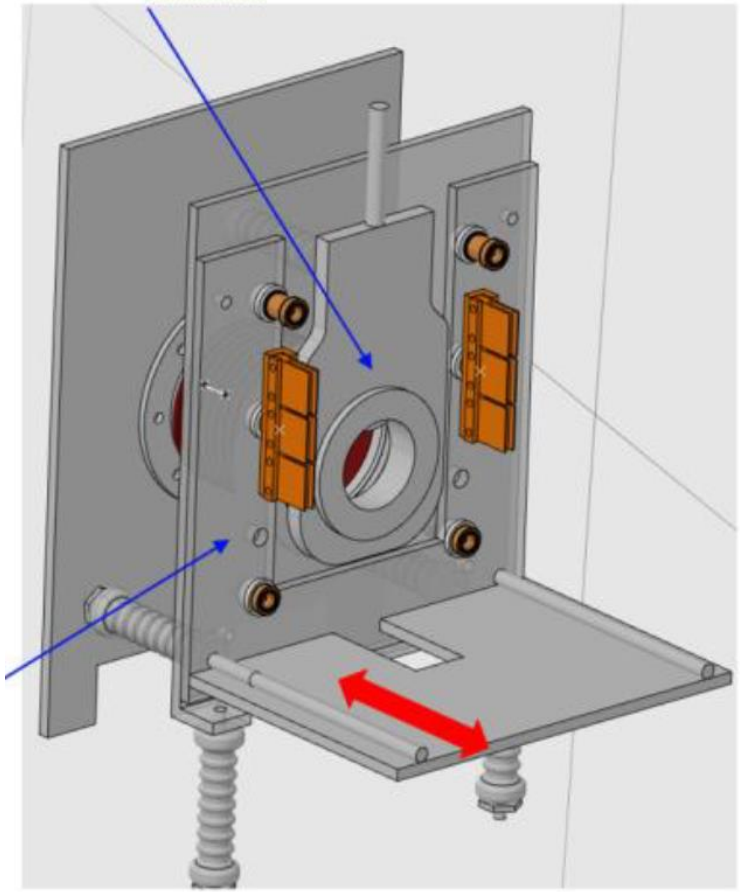


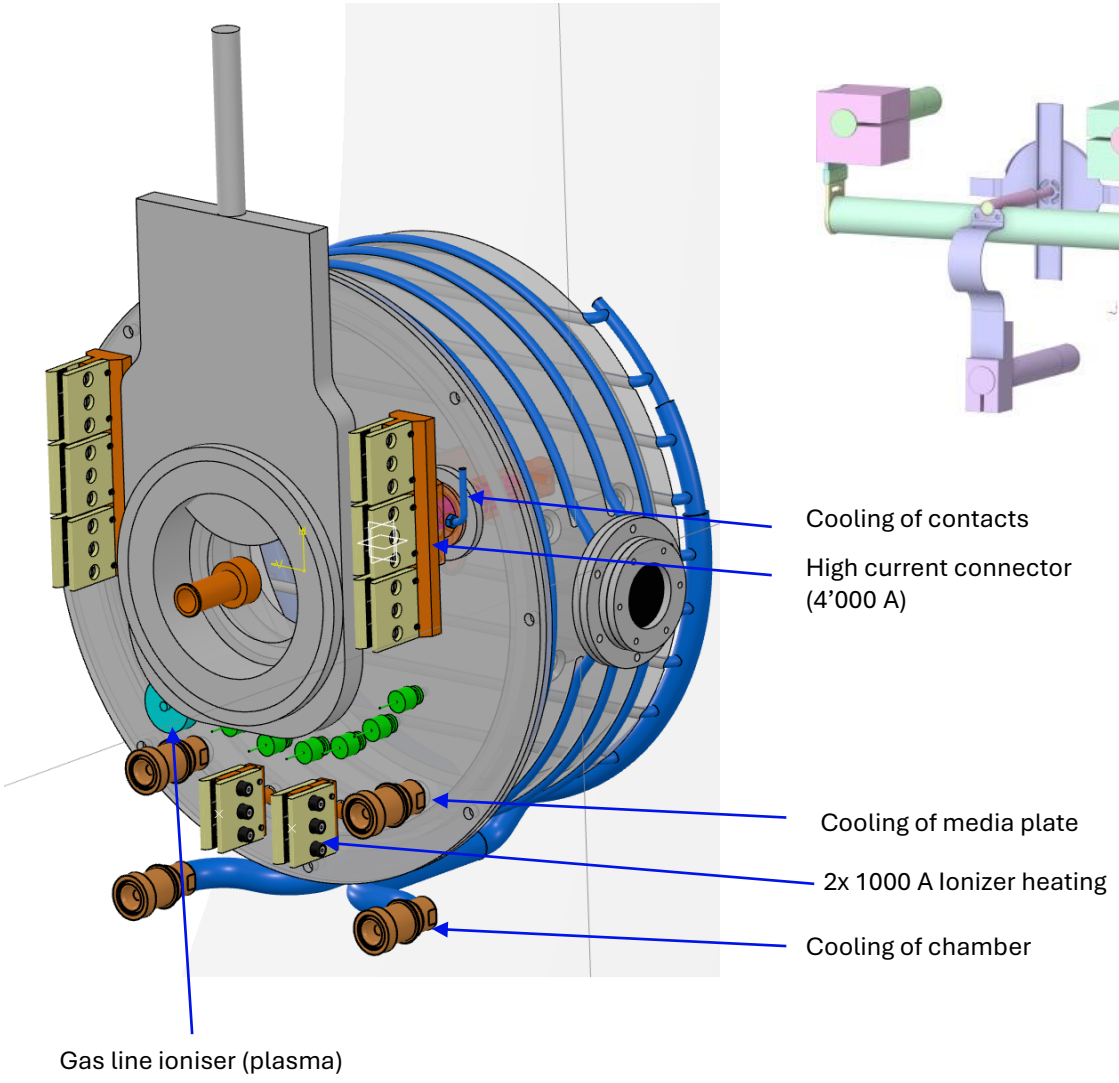
Beam wobbler

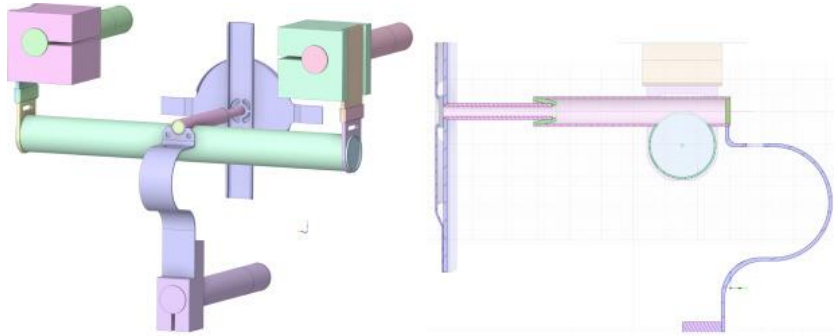




Target, target chamber & media supply (prelim. concept)





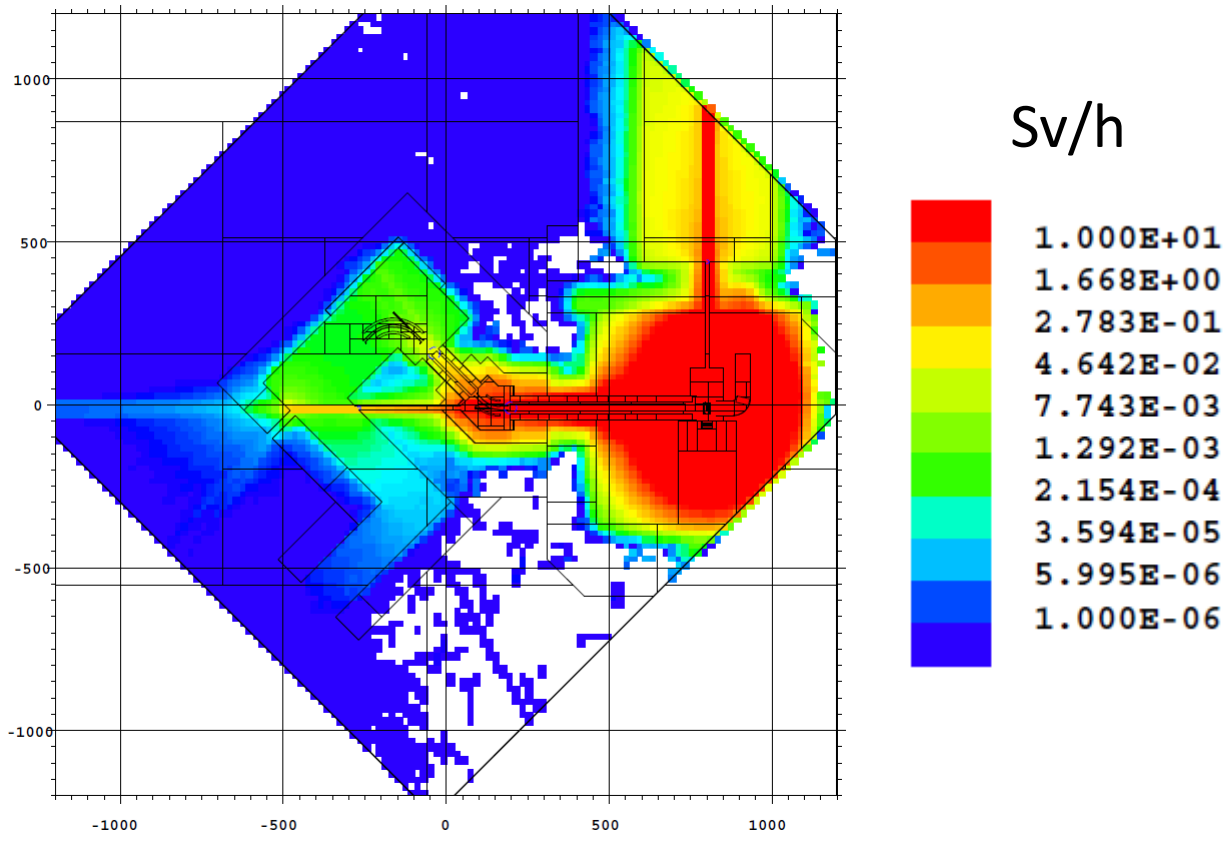


ISOLDE-type target

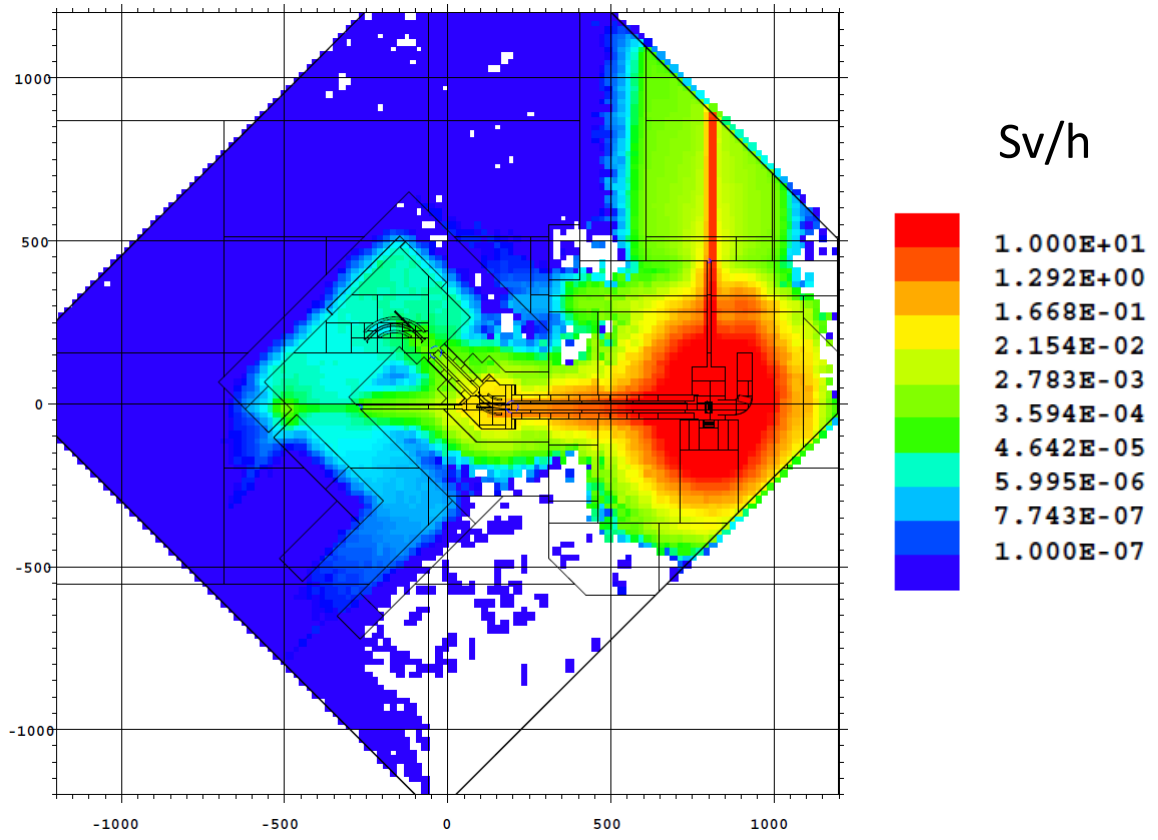
In-situ Dose & Shielding Target

PSI

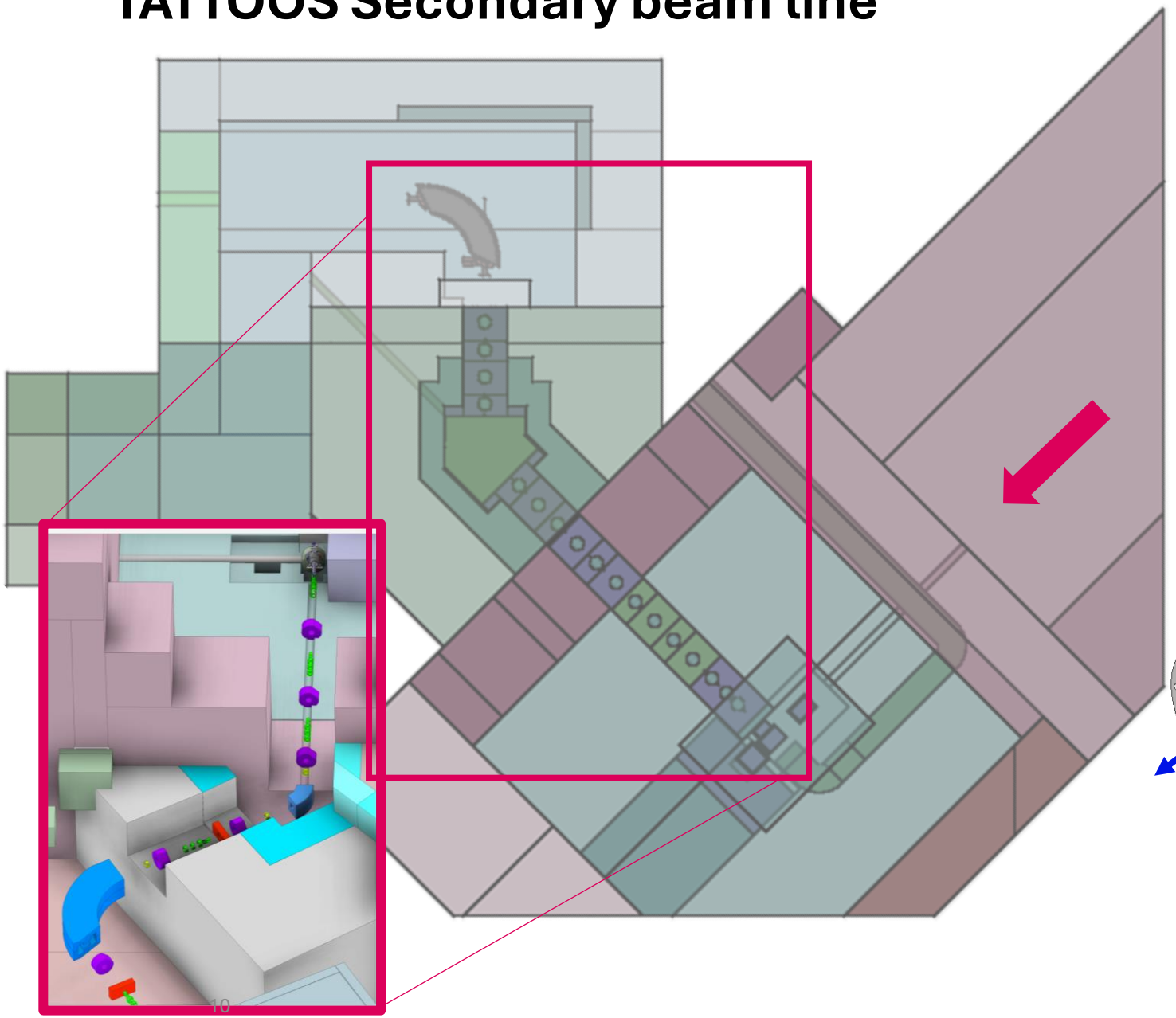
Neutrons

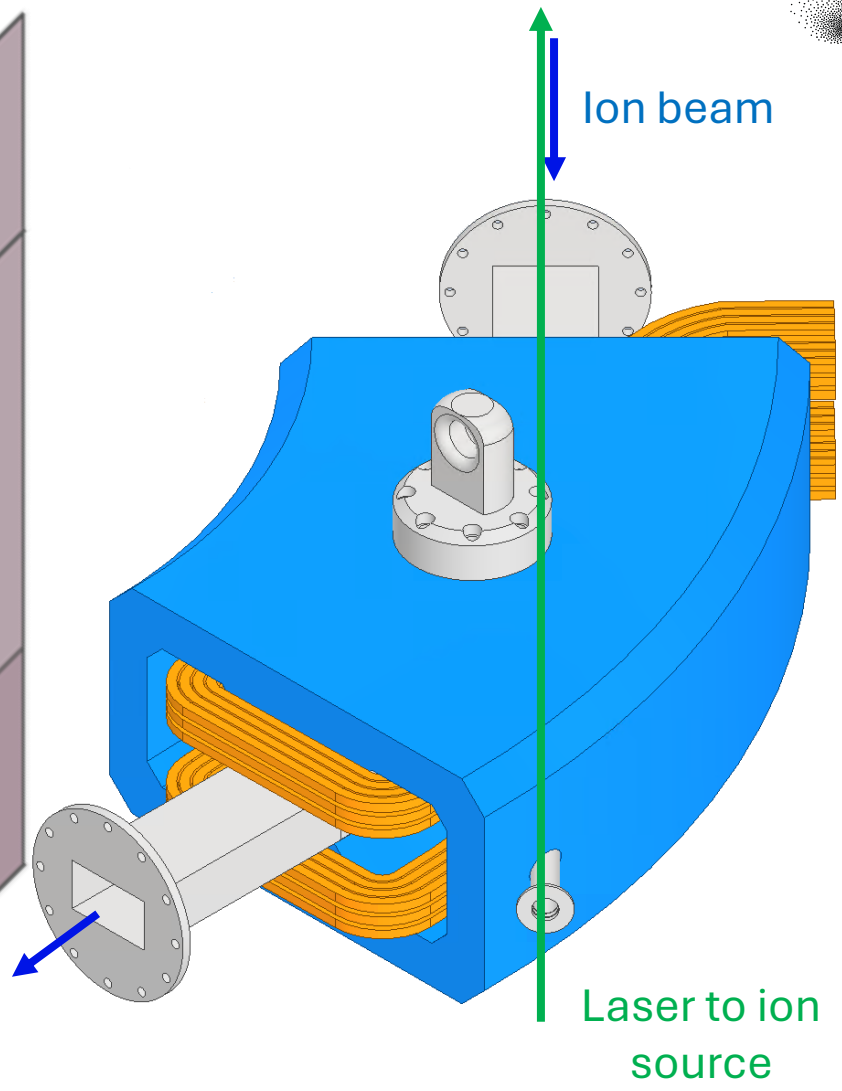


Gamma

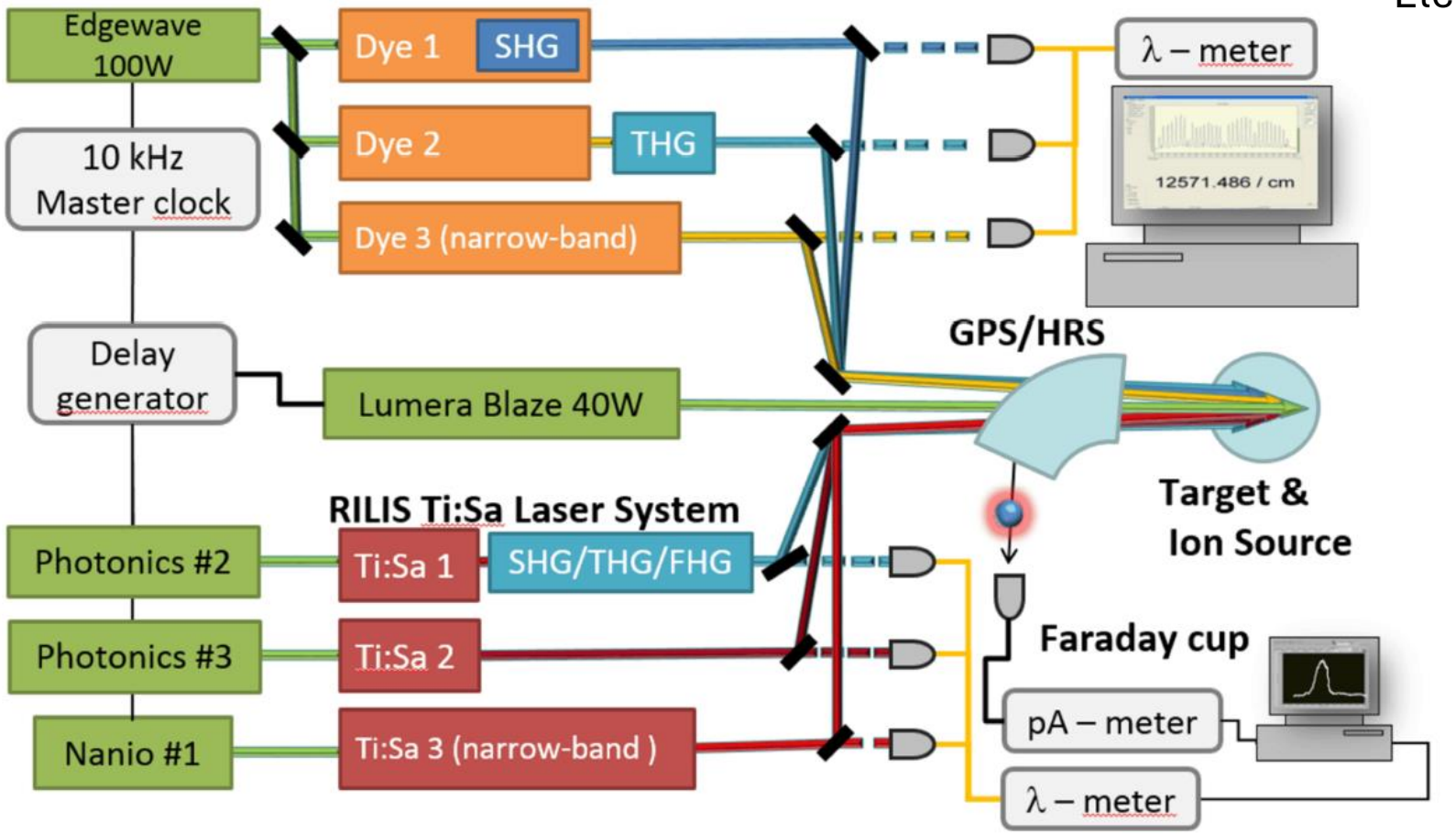


TATTOOS Secondary beam line





Ionization Laser Resonance (RILIS)



Element specific:

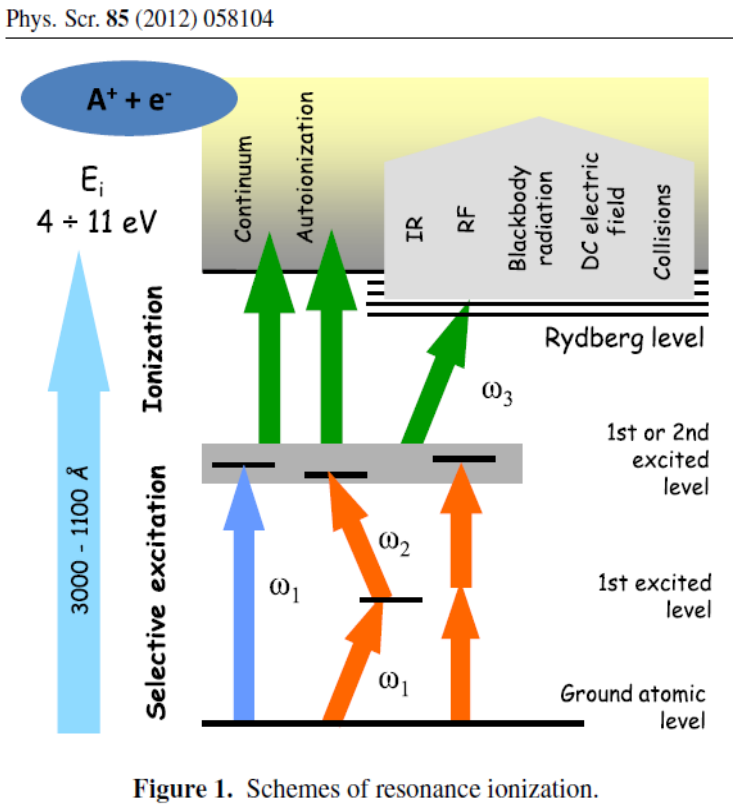


Figure 1. Schemes of resonance ionization.

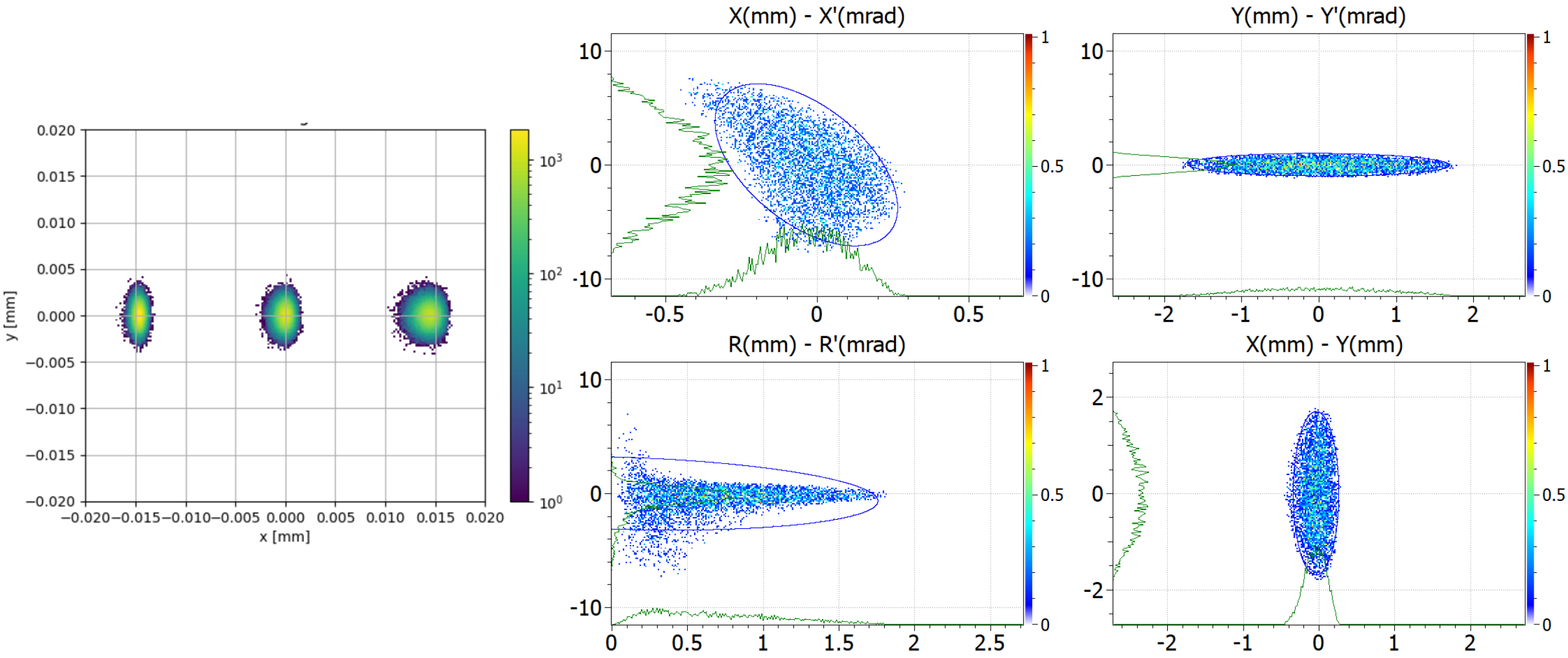
IOP Publishing Physica Scripta
Phys. Scr. 85 (2012) 058104 (14pp) doi:10.1088/0031-8949/85/05/058104

Resonance laser ionization of atoms for nuclear physics

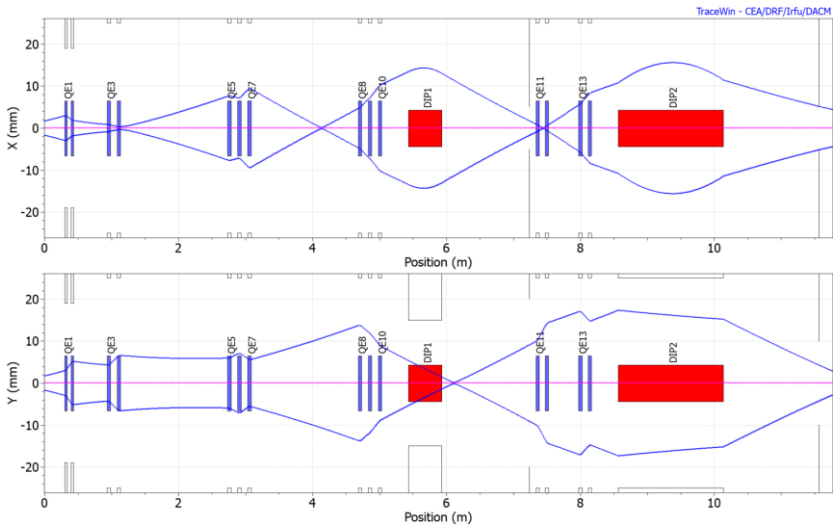
V N Fedosseev[1], Yu Kudryavtsev[2] and V I Mishin[3]

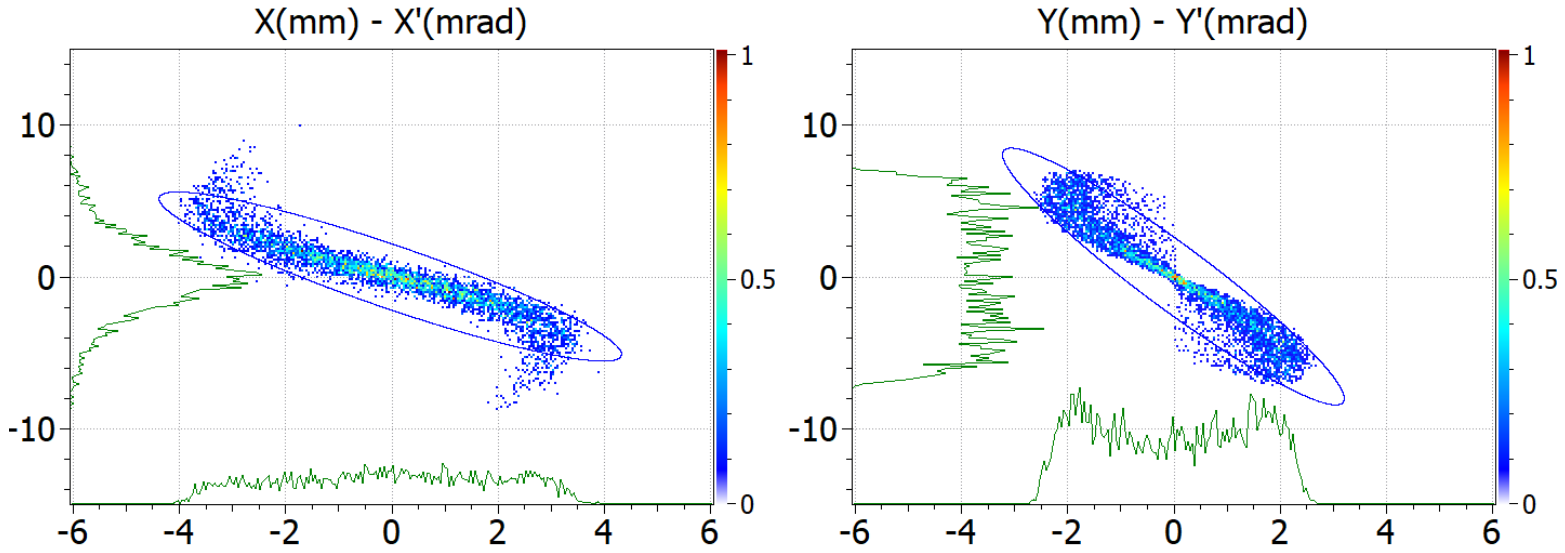
doi:10.1088/0031-8949/85/05/058104

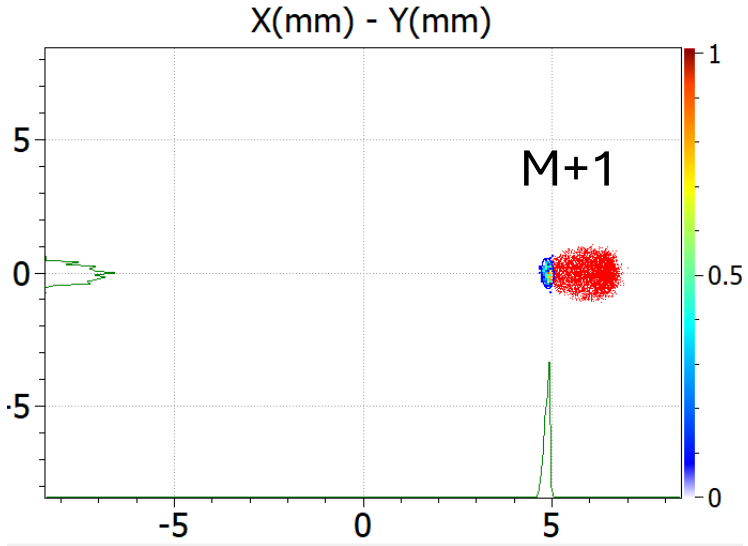
Mass separation simulation @ ion beam of 0.1 uA

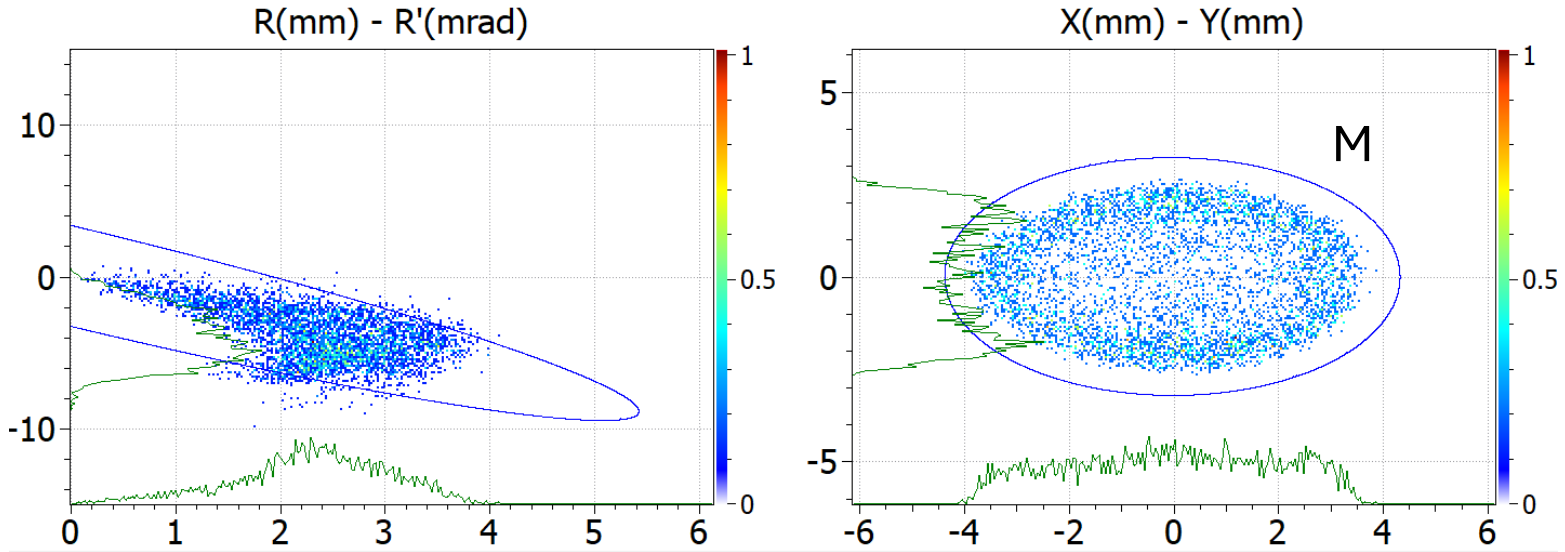


Mass separation simulation @ ion beam of 10-20 uA

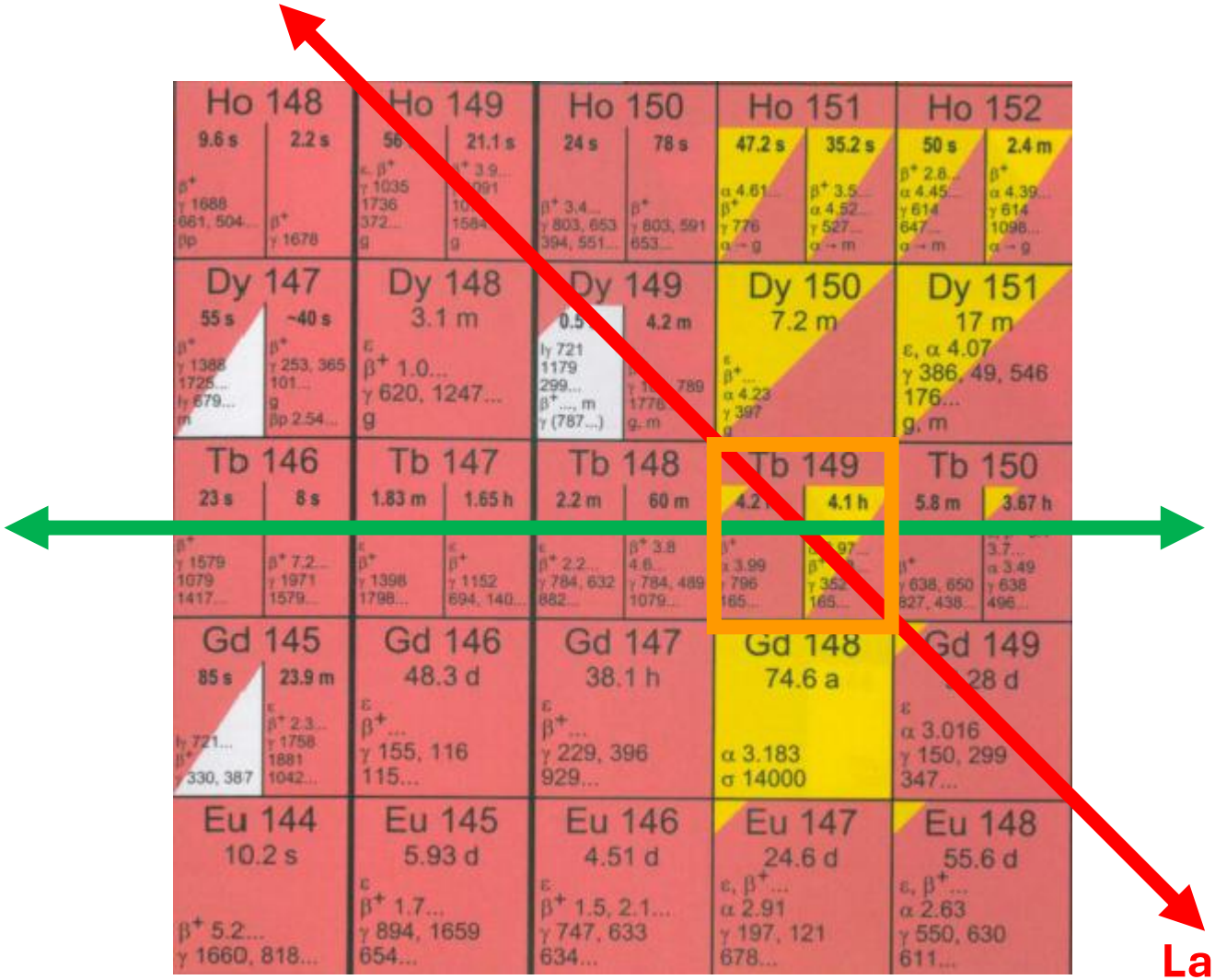








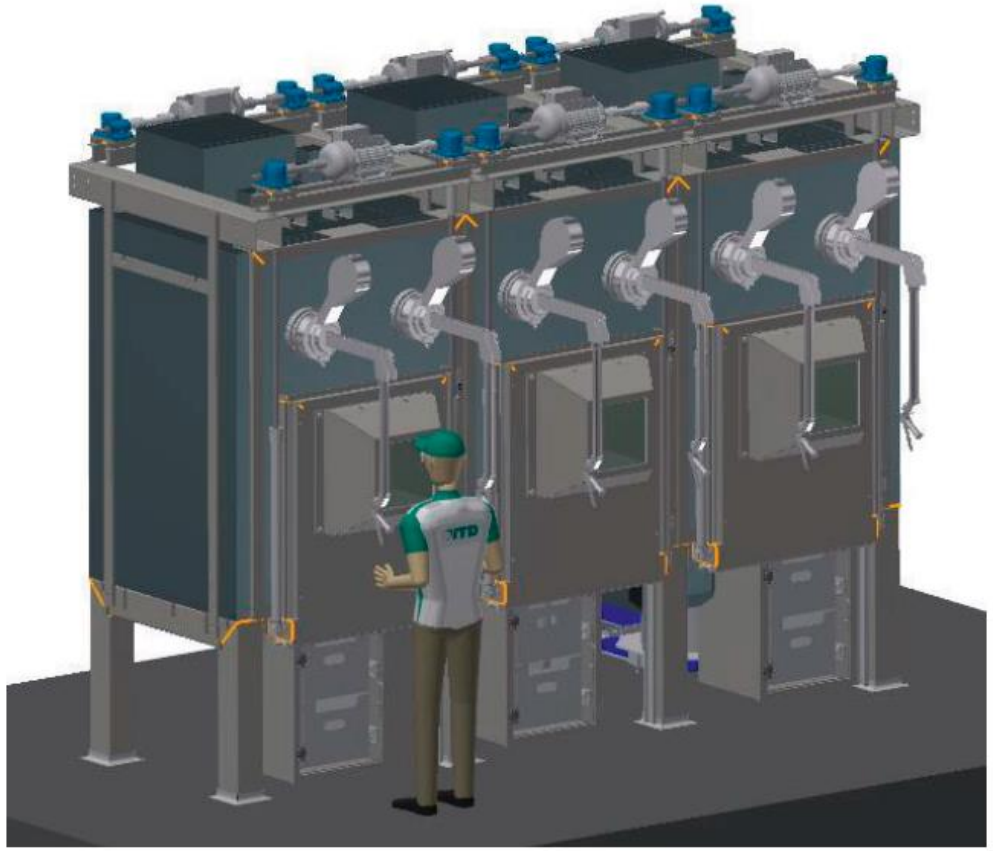
The ISOL – principle e.g. Terbium-149

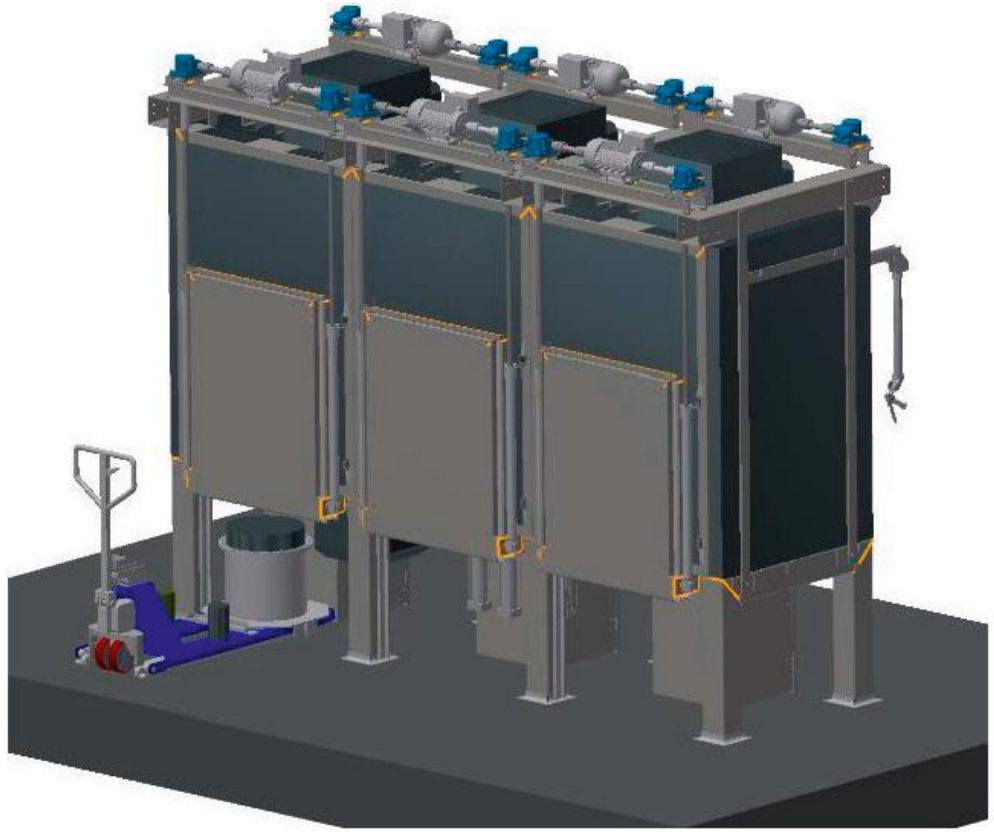


Mass Separation
isotope specific

Laser Resonance Ionization
element specific

Ion sampling and radiochemical separation of mass isobars in shielded cells





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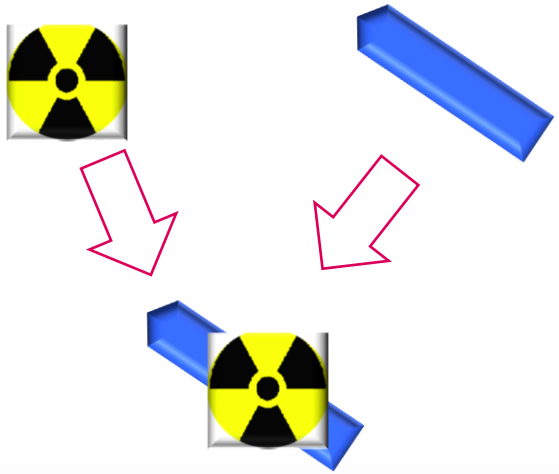
The integrated radiopharmaceutical approach @ PSI through a joint effort

Center for Nuclear Engineering and Sciences (NES)

Laboratory of Radiochemistry

Expertise in Isotope production, chemical separation and handling, fundamental radiochemical research



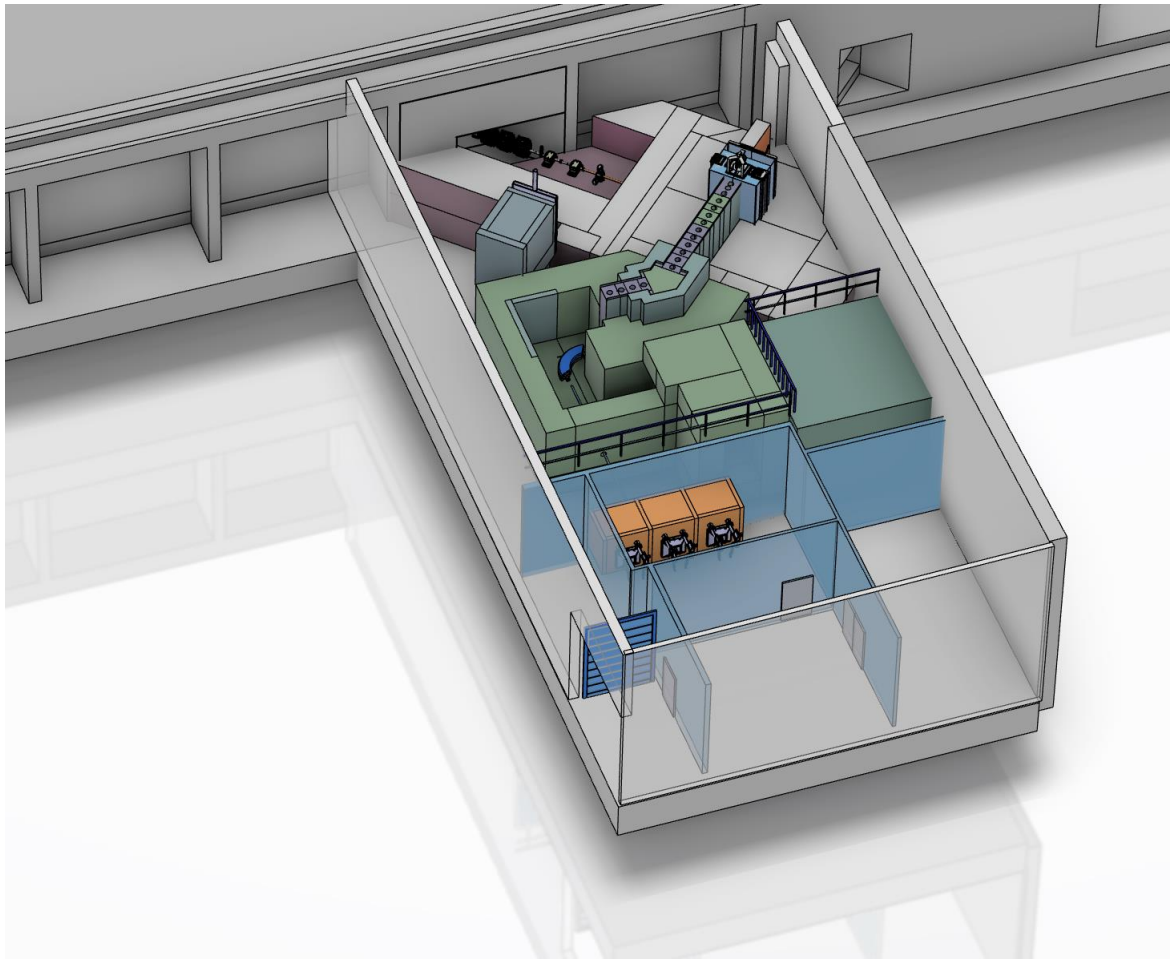
Center for Life Sciences (CLS)

Center for Radiopharmaceutical Sciences

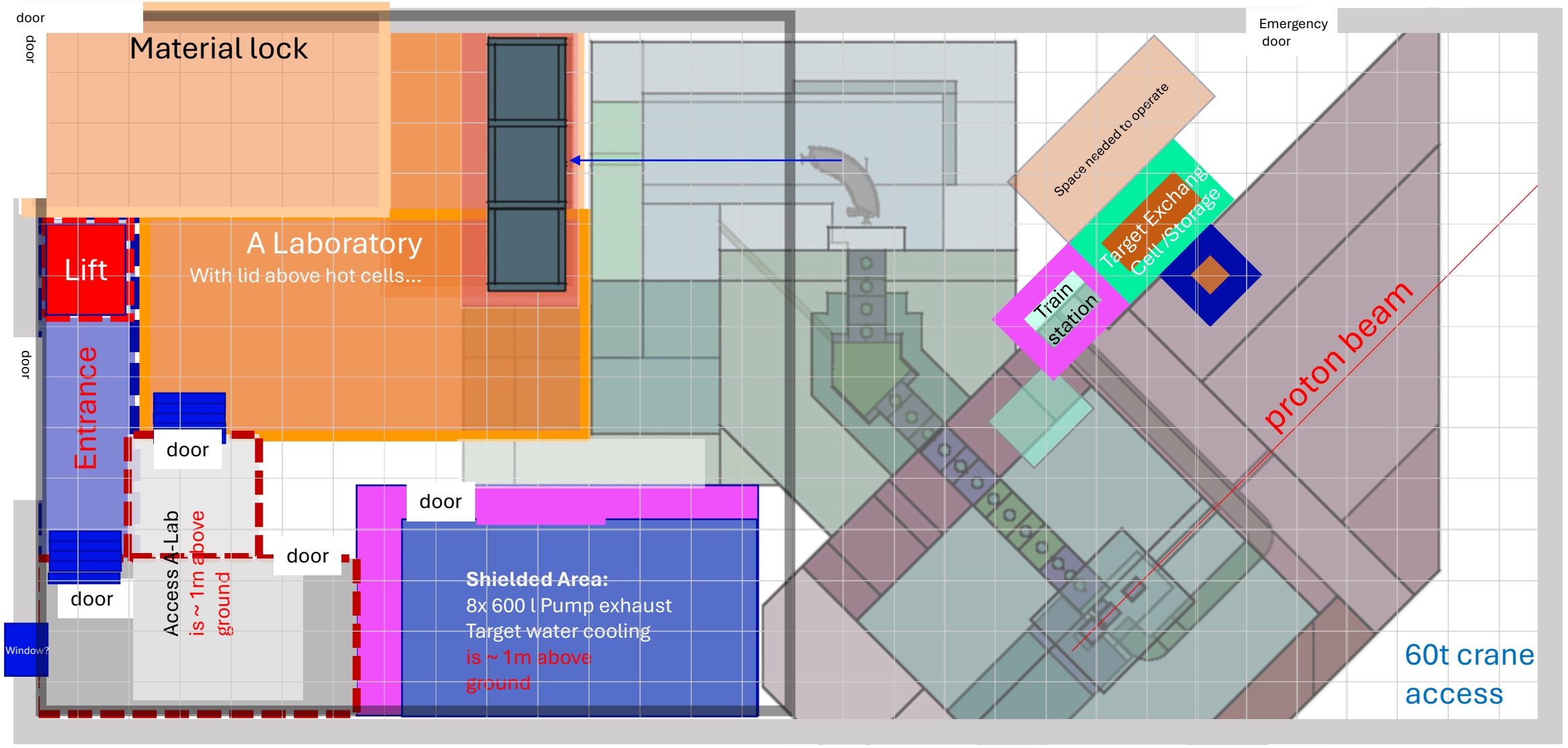
Expertise in Radiolabeling chemistry, Preclinical assessment and Radionuclide therapy development, GMP

Radionuclide Development group

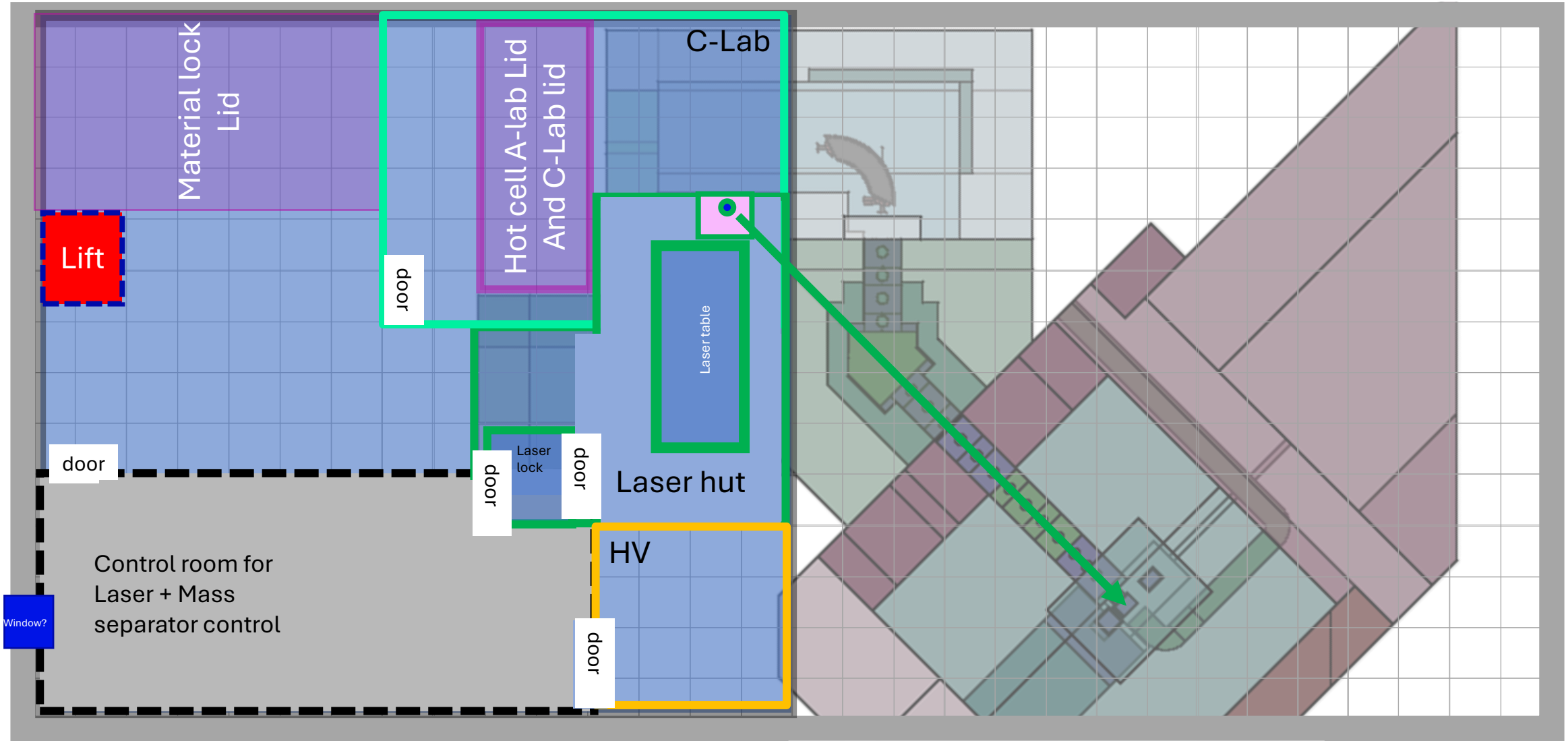
TATTOOS Building



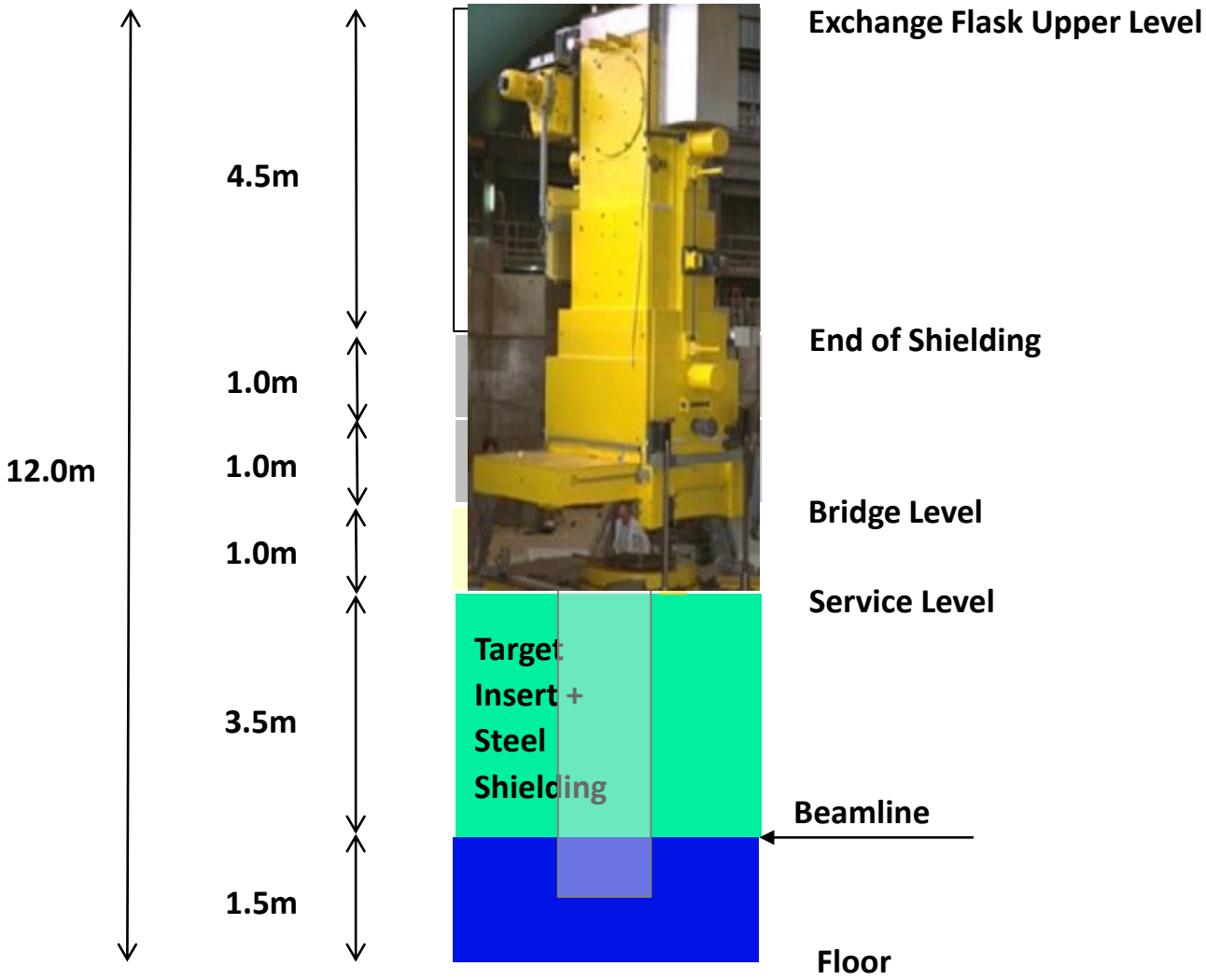
Ground floor



Second floor on ~5m height



Required TATTOOS Building Height

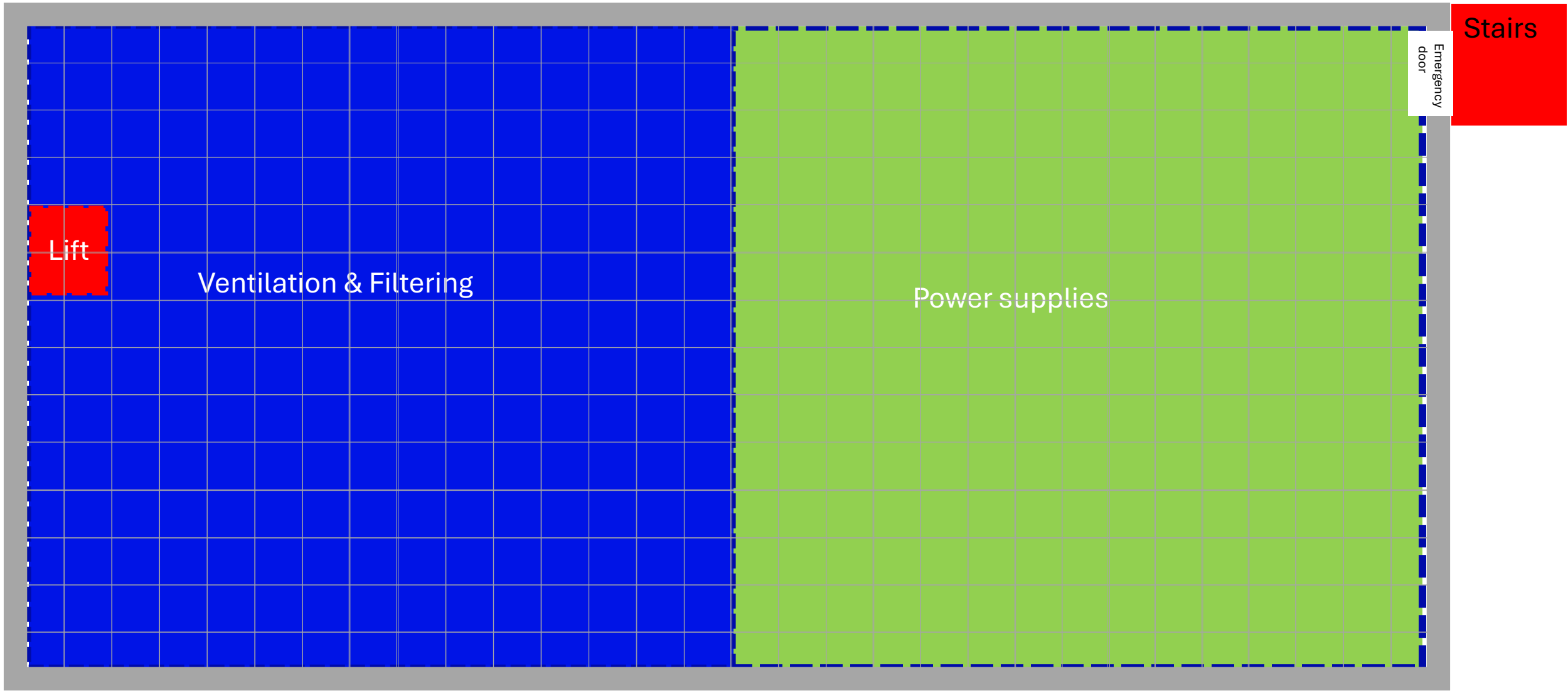


Full Building:

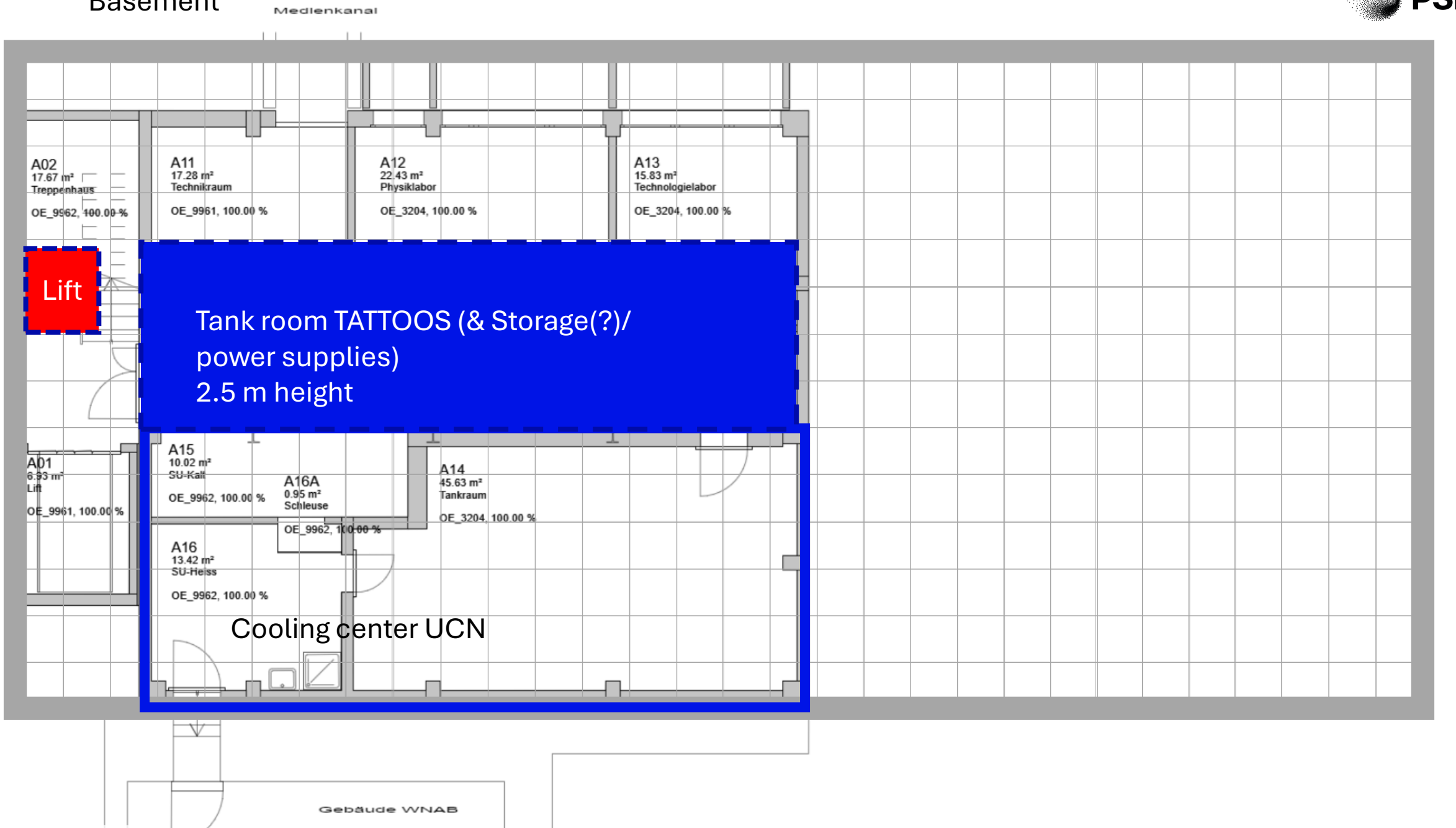
14 m + Crane (60t) + Roof ≈ **20 m**

Rooftop

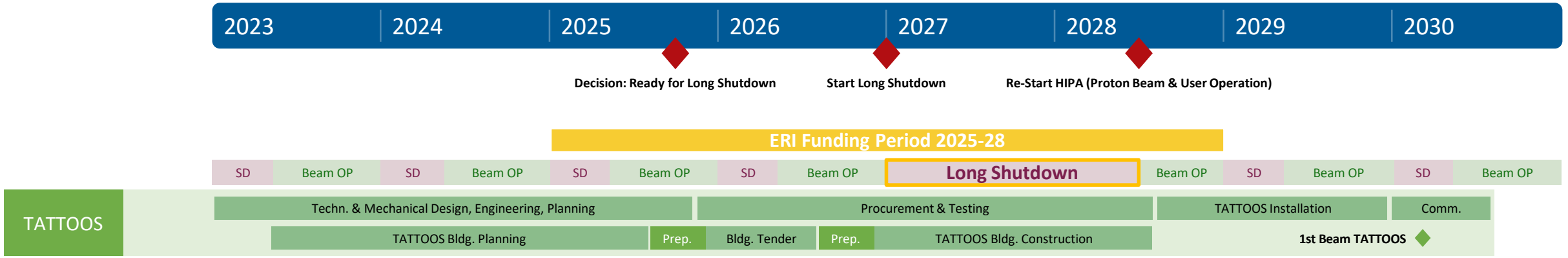
PSI


Stairs
Emergency door
Lift
Ventilation & Filtering
Power supplies

Basement


Medienkanal
A02
17.67 m²
Treppenhaus
OE_9962, 100.00 %
A11
17.28 m²
Technikraum
OE_9961, 100.00 %
A12
22.43 m²
Physiklabor
OE_3204, 100.00 %
A13
15.83 m²
Technologielabor
OE_3204, 100.00 %
Lift
Tank room TATTOOS (& Storage(?)/ power supplies)
2.5 m height
A01
6.93 m²
Lift
OE_9961, 100.00 %
A15
10.02 m²
SU-Kalt
OE_9962, 100.00 %
A16A
0.95 m²
Schleuse
OE_9962, 100.00 %
A14
45.63 m²
Tankraum
OE_3204, 100.00 %
A16
13.42 m²
SU-Heiss
OE_9962, 100.00 %
Cooling center UCN
Gebäude WNAB

Time-line TATTOOS



TATTOOS Collaboration

R. Eichler [1,2]*, N. van der Meulen[1,3], D. Kiselev[4], C. Baumgarten[4], A. Ivanov[4], S. Jollet[4], M. Hartmann[4], S. Harzmann[4], D. Laube[4], M. Mostamand[3], N. Preiss[4], T. Rauber[4], D. Reggiani[4], J. Snuverink[4], S. Warren[4], H. Zhang[4]

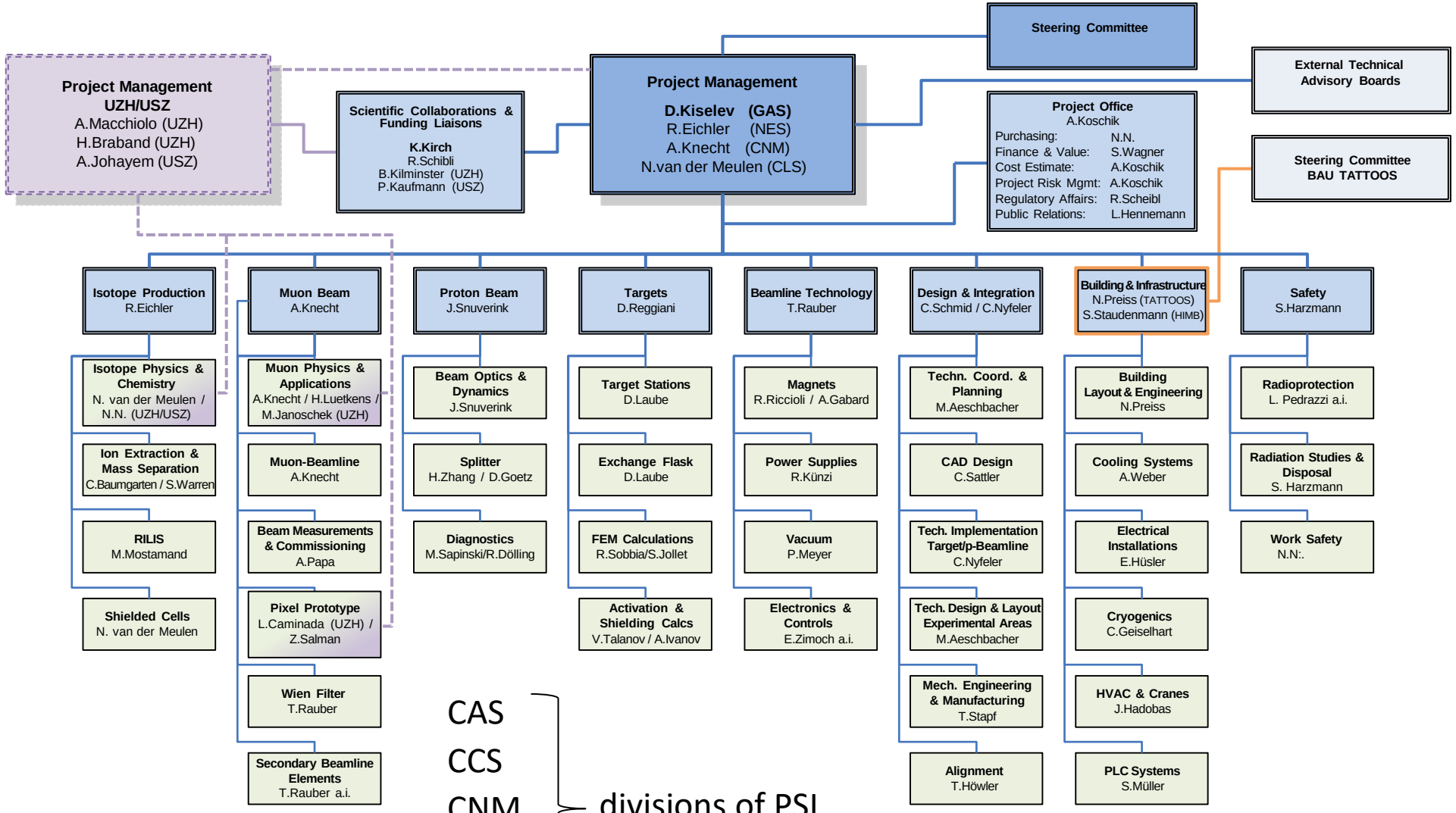
[1] Laboratory of Radiochemistry, Paul Scherrer Institute, Villigen PSI, Switzerland

[2] Department of Chemistry, Biochemistry and Pharmacy, University of Bern, Bern, Switzerland

[3] Center for Radiopharmaceutical Sciences PSI-ETHZ, Paul Scherrer Institute, Villigen-PSI, Switzerland

[4] Center for Accelerator Science and Engineering, Paul Scherrer Institute, Villigen PSI, Switzerland

Organigram “People of IMPACT”



TATTOOS as Part of the IMPACT Proposal is on the Roadmap of Swiss Research Infrastructures for 2025-28

https://www.psi.ch/en/impact

https://www.sbfi.admin.ch/dam/sbfi/en/dokumente/2023/06/roadmap_forschungsinfrastrukturen_2023_teil_1.pdf.download.pdf/Roadmap_Forschungsinfrastrukturen_2023_Teil_1_EN.pdf

Calculated Production Rates at TATTOOS

PSI

Radionuclide Produced				CERN 2uA 600MeV	TATTOOS 100uA 590MeV*	Calculated patient doses
Element	Mass number	Target material	$T_{1/2}$	Irradiation time: 12h	Irradiation time: 6d	
				GBq**		
Tb	***149***	***Ta***	***4.118 h***	***0.375***	***21***	*No reference*
Tb	***152***	***Ta***	***17.5h***	***0.038***	***5***	*No reference*
Tb	***155***	***Ta***	***5.32d***	***0.006***	***3***	*No reference*
Tm	*165*	*Ta*	*30.06 h*	*0.532*	*106*	*No reference*
Er	*165*	*Ta*	*10.36 h*	*0.662*	*60*	*No reference*
Ac	***225***	***UCx***	***9.92d***	***0.021***	***10***	***Ca. 1'300***
Ra	225	UCx	14.9d	0.014	7	Ca. 700
Ac	***225***	***ThCx***	***9.92d***	***0.024***	***12***	***Ca. 1'500***
Ra	225	ThCx	14.9d	0.012	6	Ca. 800
Rn	*211*	*ThO2*	*14.6h*	*0.139*	*12*	*Ca. 50*
Ra	***223***	***ThCx***	***11.43d***	***0.036***	***19***	***Ca. 4'500***

* theoretical calculations; ** assuming ISOLDE yields